National Renewable Energy Laboratory

DOE Hydrogen Program

Systems Analysis Workshop

Washington D.C.
28-29 Jul 04

Dale Gardner
Systems Integration

Topics

- Meeting Goals
- Systems Integration
- Roles/Responsibilities of Analysis Participants
- Systems Analysis
- From this Workshop
- Capability Presentations

Meeting Goals

1) Understand the roles and activities of the DOE Technology Analyst, Systems Integration, and each Analysis group
2) Discuss the NRC recommendations pertaining to Analysis
3) Identify analysis gaps and overlap
4) Determine methods for coordinating analysis
   - Document analysis capabilities and tools
   - Document gaps
   - Determine how to share data
5) Determine the major issues in each analysis domain
6) Determine the key questions that analysis should address (help develop the Analysis Agenda)
7) Discuss the need for common assumptions when performing cross-cutting analysis
   - Determine how to set up those common assumptions
8) Discuss development of a repository for
   - Agenda of analysis tasks
   - Analysis results
   - Common assumptions for cross-cutting analysis
9) Develop a list of potential analysis resources along with their skills and capabilities

Systems Integration

Definition

In the Development world (i.e., building systems) --

- Systems Integration is the process of assembling the constituent parts (e.g., subsystems, components) of a system in a logical, cost-effective way to support the subsequent testing, verification that the system meets its requirements, and validation that the system performs in accordance with the customer/user expectations.

In our Research & Development world --

- Out intent is for Systems Integration to utilize appropriate processes (but modified), in order to support the planning and execution of complex R&D programs and ensure synergy/coordination among program elements/projects. Overarching Systems Engineering practices will also be applied, where applicable, to support program planning and decision-making.

Hydrogen Systems Integration Overview

PURPOSE

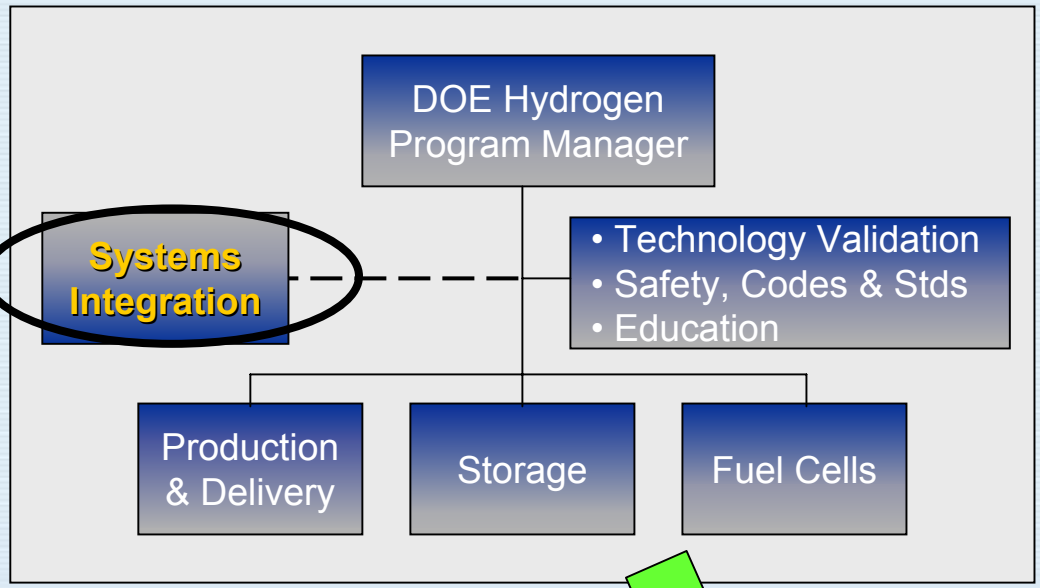
- *Deliver independent and objective analyses, advice, and planning options*
- *Provide information to help the DOE Hydrogen Program Manager in making informed decisions*
- *Support successful technology development and validation and enable a positive Commercialization Decision in 2015.*

CONTEXT

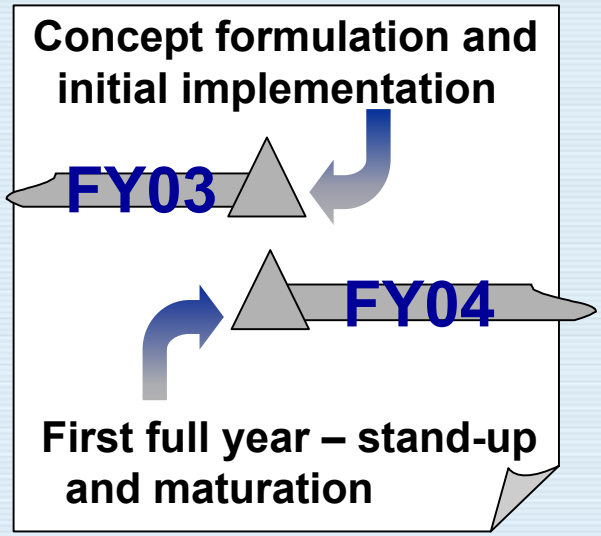
- *Support a results-driven Program approach consistent with President's Management Agenda*
- *Provide assistance in managing the complex interactions between inter-related technical and programmatic elements*
- *Respond to DOE/EERE desire to implement applicable Systems Engineering principles and processes within its Program structure*

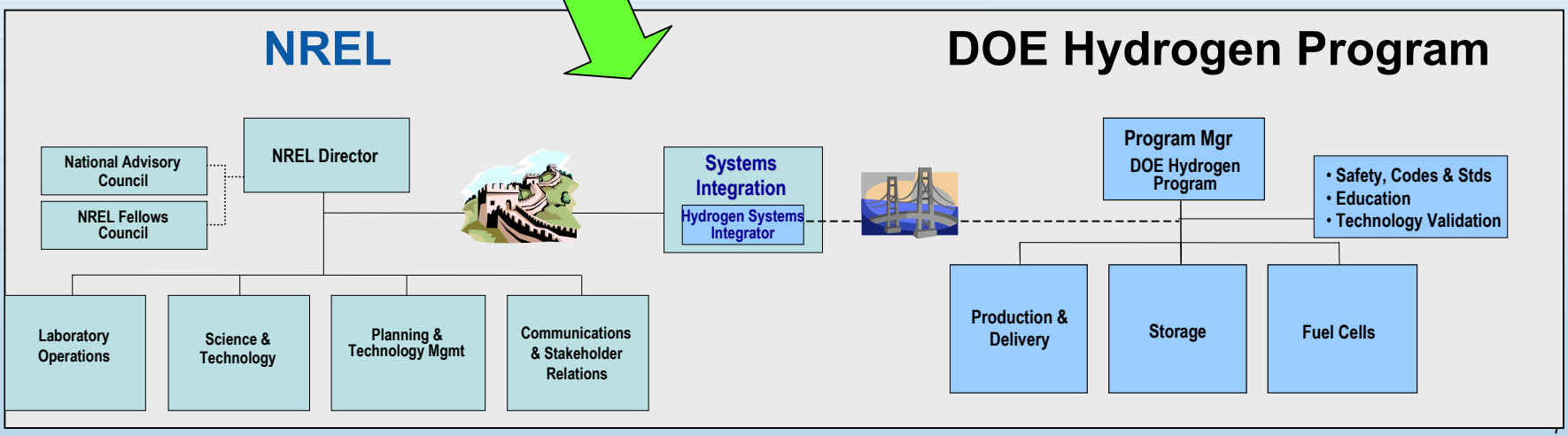
Overview

ORGANIZATION



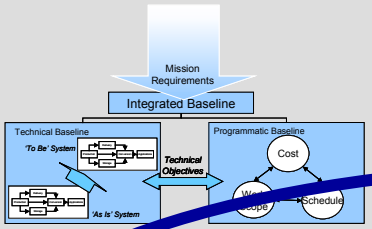
TIMELINE



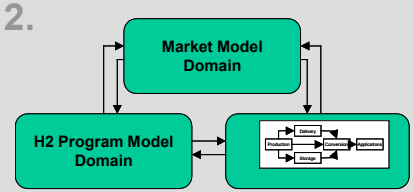


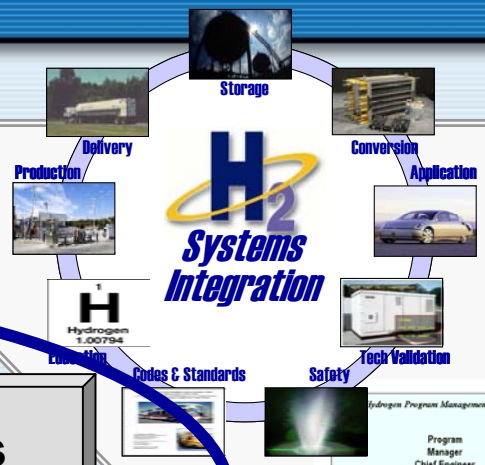
Systems Integration Functions

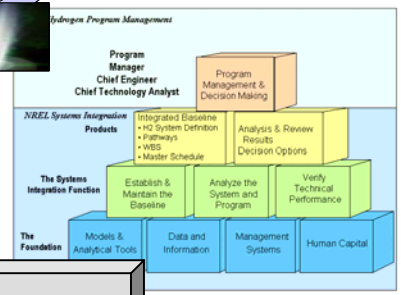
1. **Produce/Maintain Program Integrated Baseline**



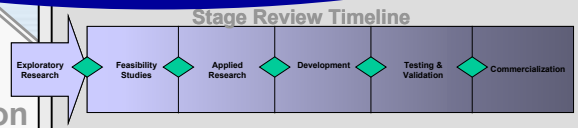
2. **Provide Systems Analysis & Modeling**







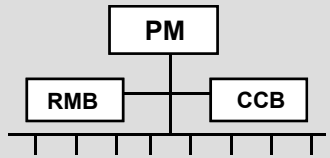
3. **Verify Technical Performance**



Supporting Tasks:

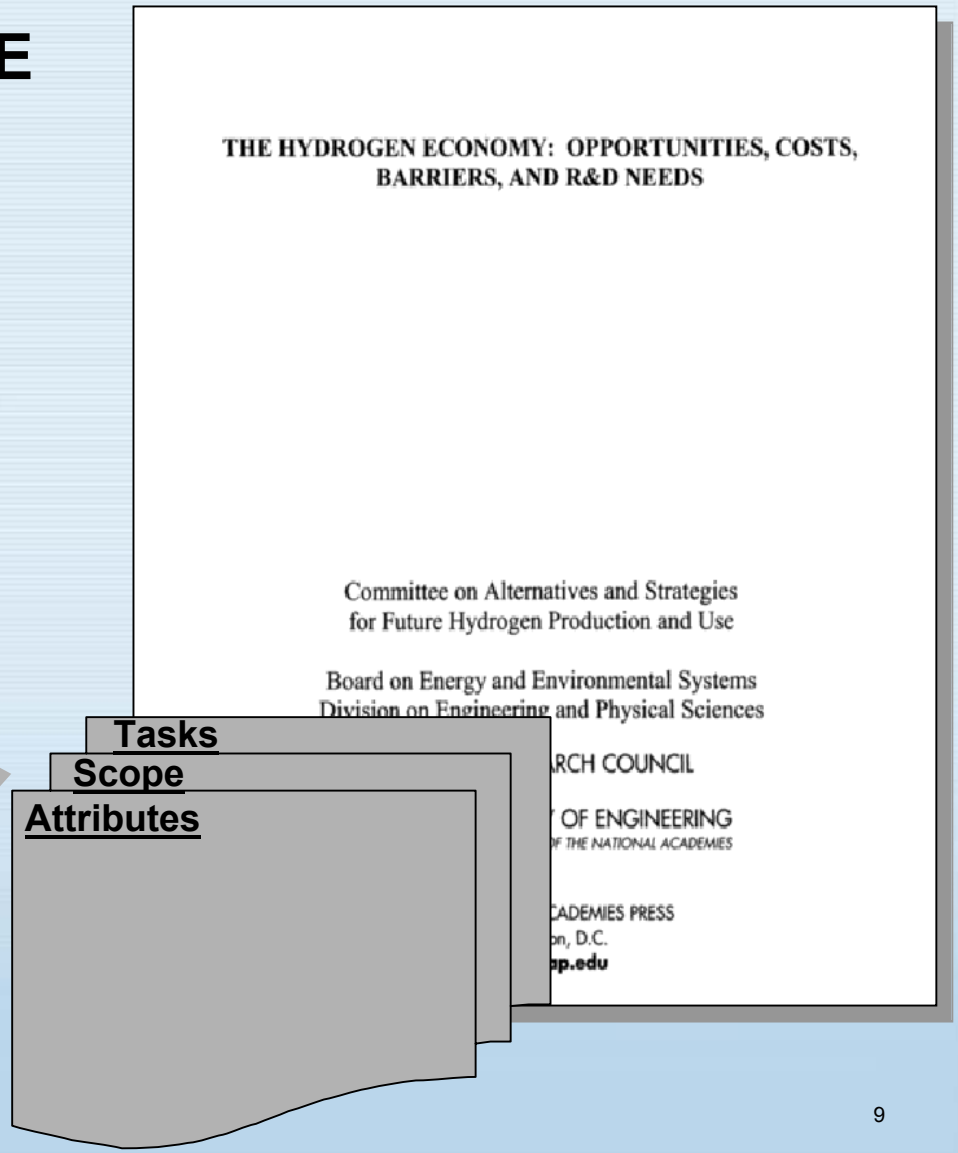
- Assemble team
- Produce Systems Integration Plan
- Develop Systems Integration detailed schedule
- Establish FE/NE/SC, Lab, & Industry relationships
- Provide FreedomCAR & Fuels Technical Team support
- Develop Systems Integ briefing/roadshow
- Prepare for Internal & External assessments

4. **Implement Systems Engineering Processes**



NRC Report

- 2002 Commissioned by DOE
- 2003 Interim Report
  - Systems Analysis
  - Exploratory Research
  - Safety
  - Organization
- 2004 Final Report
  - Concentrate on Transition
    -
    -
    -
  - Implement Systems Analysis



Roles & Responsibilities

Roles & Responsibilities

TECHNOLOGY ANALYST

- Accountable for analysis activities
- Provide inputs/priorities to the Analysis Agenda
- Advises PM on policy issues
- Assure communication of a consistent set of data and info
- Provide analysis which is an inherent Govt responsibility
- Provide analysis in response to short-term and urgent requests (quick-response tasks)
- Primary direction/guidance interface with TDMs/subprograms and Tech Teams
- Provide analysis coordination within DOE (EERE programs, Offices, PBA, EIA)
- Interpret analysis scenarios provided by SI

NREL SYSTEMS INTEGRATION

- Develop Analysis Agenda (including technical and time pathways)
- Develop, maintain, resolve consistent data sets/info and standard analysis assumptions and guidelines
- Provide independent analysis (policy-related issues, Go/No-Go recommendations, H2 in the context of larger energy markets, etc.)
- Ensure tools/models are developed, maintained, available, validated
- Provide independent review of analysis results
- User and/or requestor of info generated by TA (especially from other parts of DOE)
- Define analysis scenarios

DOE Subprogram TDMs

- Provide inputs/priorities to Analysis Agenda
- Coordinate and provide ideas/recommendations to SI on cross-cutting analysis
- Manage analysis tasks internal to subprogram
- Provide internal planning/results back to SI and TA

Roles & Responsibilities (cont)

TECHNOECONOMIC ANALYST COMMUNITY

- Provide analysis strategic recommendations and planning inputs to DOE (Labs/FFRDCs only)
- Perform analysis of technical and policy topics to TA and SI
- Perform subprogram analysis in support of TDMs
- Develop and maintain the models and tools to perform analysis
- Provide analysis of scenarios
- Report on analysis results to tech community

DOE EERE/PBA

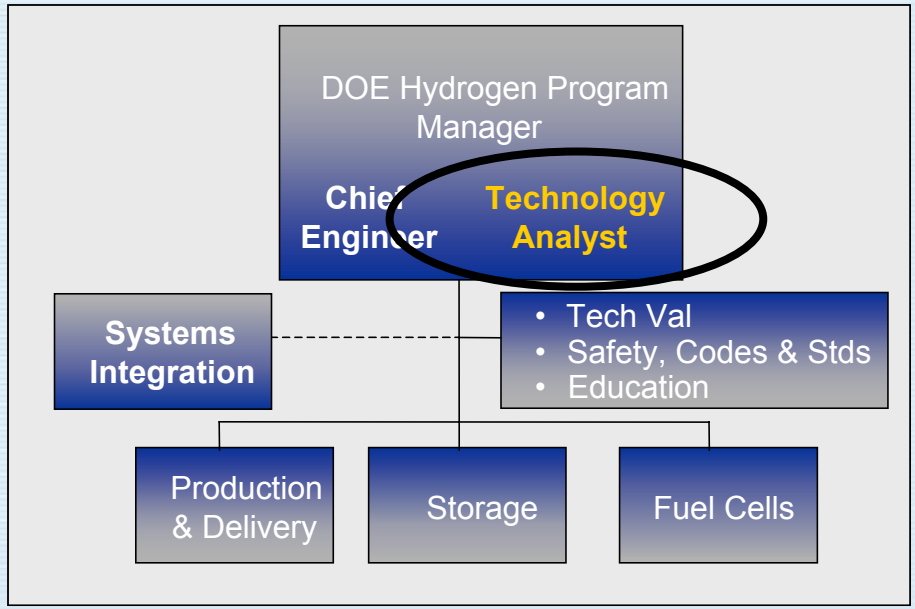
- Provide market and benefits analysis related to hydrogen and energy infrastructure
- Review Analysis Agenda inputs/priorities
- Coordinate/exchange activities and results with the TA and SI analysis team

TECH TEAMS

- Provide recommendations to DOE and SI on analysis needs, topics, issues, results, etc
- Provide inputs/priorities to the Analysis Agenda
- Review studies and analysis
- Coordinate/arrange auto and energy company analyses

Technology Analyst

DUTIES AND RESPONSIBILITIES



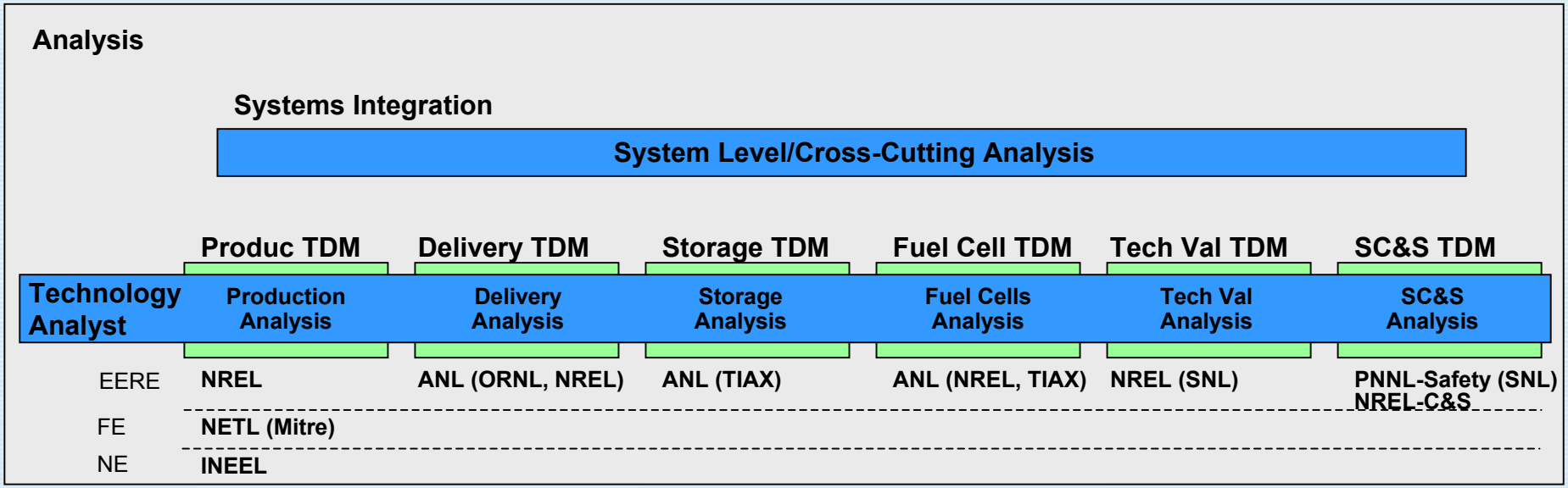
- Focal point for technology analyses
- Advises the PM on policy options to support technology commercialization
- Develops and manages activities to assess program approaches and results in overcoming technical barriers
- Points out need for new and changes to existing program guidance.
- Uses analytical models to analyze technology and material costs of technologies.
- Coordinates analysis with Systems Integration

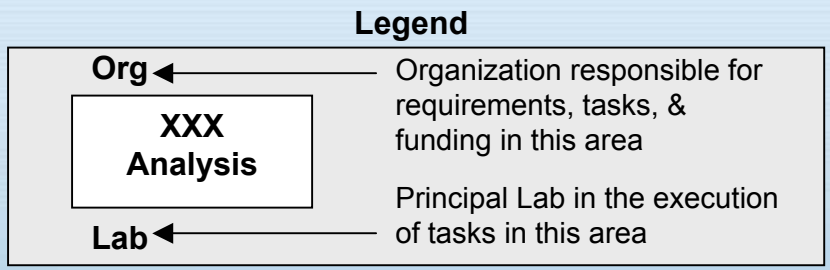
Roles & Responsibilities Observations

- **Most potential for overlap is with TA and SI**
  - **Since TA is part of HFCIT Program Mgmt, important that responsibilities which involve direction to program elements remain with TA**
  - **Also, TA must have quick-reaction analysis capabilities to respond to internal DOE, Congressional, etc. taskings**
  - **Roles will undoubtedly evolve over time**

- **SI should develop central repository for all analysis results**
  - **Also captures assumptions/guidelines**
  - **Searchable, and accessible to analysis community**

Organizational View





Organizational Summary

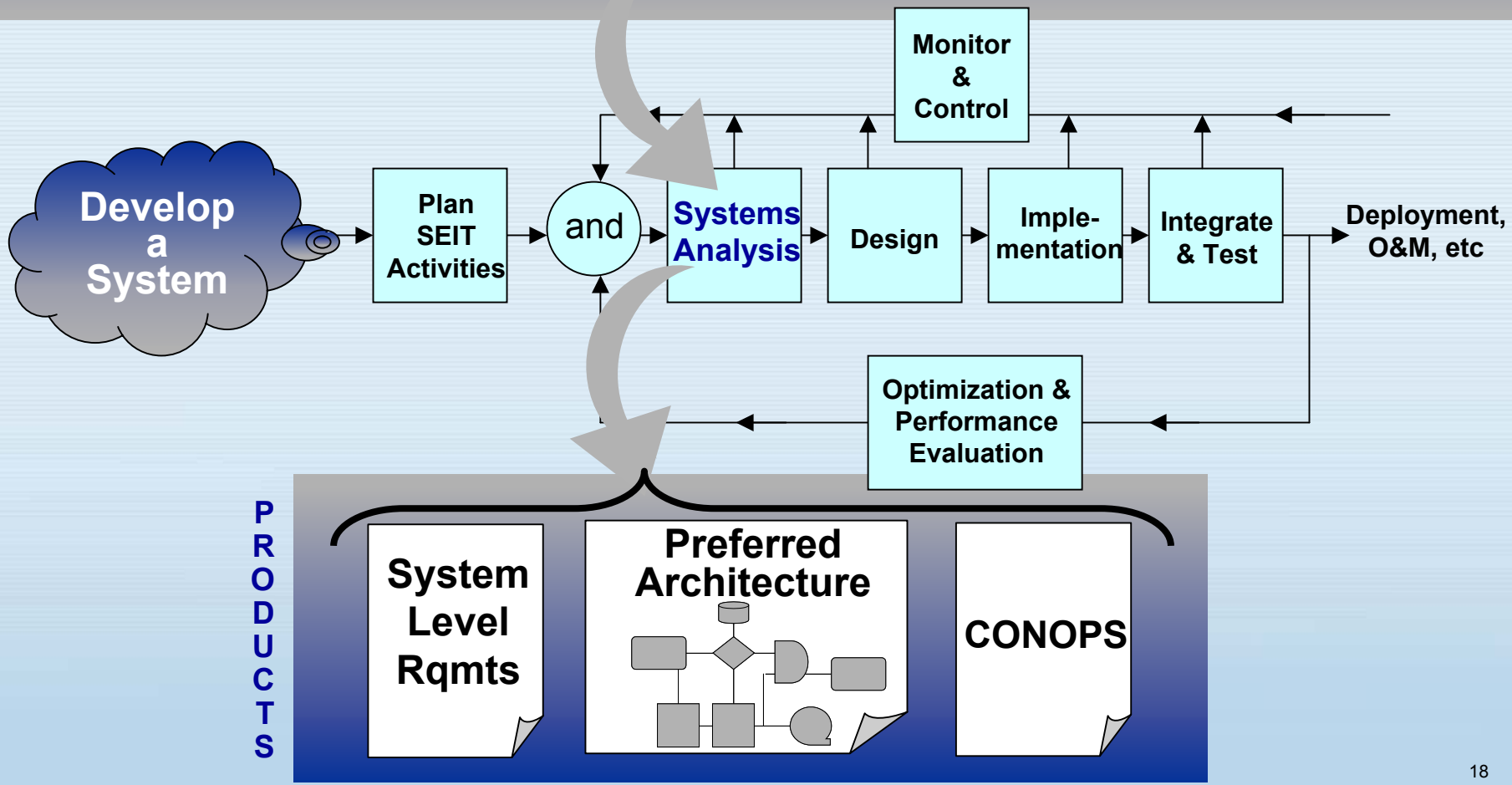
- **Principal Lab concept for subprogram areas**
  - **Need to work out/evolve the details**
  - **Assistance from TDMs**
  - **Overall guidance/direction from TA**
- **Integrate FE and NE into the construct (little analysis in SC)**

Systems Analysis

Systems Analysis

Classical/Development Systems Analysis

- Concurrent Requirements, Architecture, and Operational analysis tasks
- Produces documentation which serves as Baseline for system development



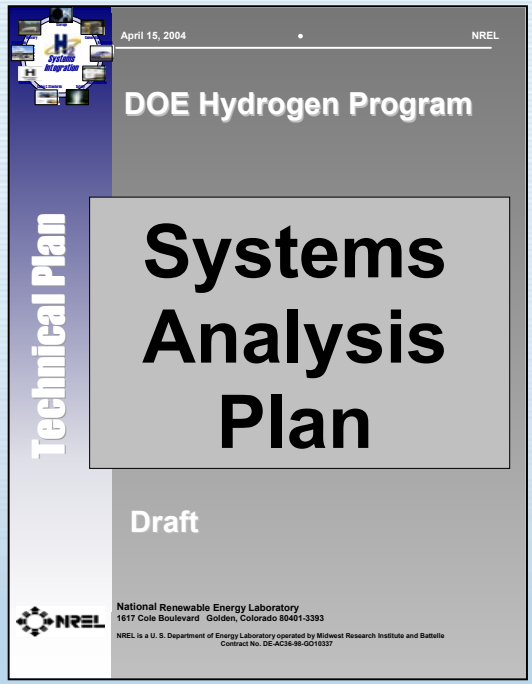
Hydrogen Systems Analysis

Systems Integration tasks include:

- support the Technology Analyst
- recommend an Analysis Agenda,
- develop and maintain common set of analysis guidelines and assumptions,
- recommend the use of other analytic tools
- develop Macro-System Model requirements and implementation
- conduct specific independent analyses,
- integrate/interpret that performed by others,
- ensure that analysis results are peer reviewed, and
- use analysis results to develop options and recommendations, and identify risks and opportunities, for consideration by the DOE Hydrogen Program.

Systems Analysis Plan

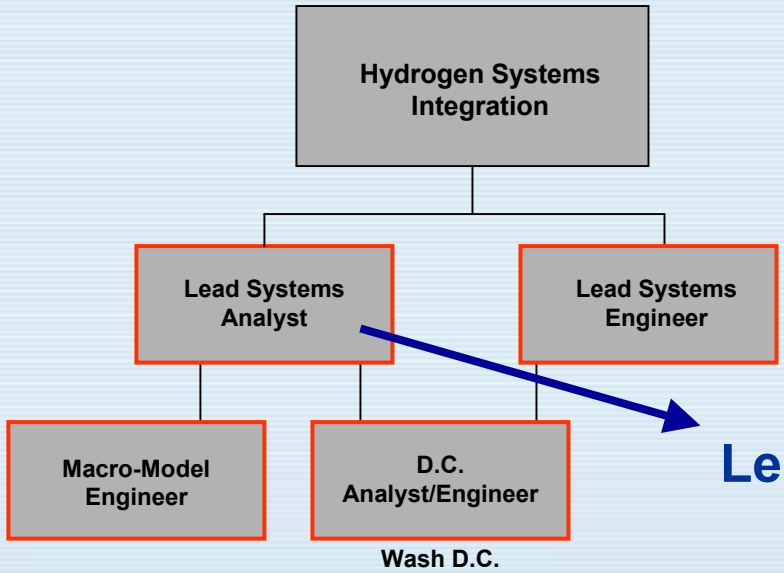
- **Catalog of Resources**
  - Survey of community analytical assets, areas of expertise, availability
  - Description of models/tools, applicability, analytical role
  - Matrix of potential utilization of above for Systems Analysis tasks
- **Systems Analysis processes**
  - Development, inputs/updates, and prioritization of Analysis Agenda
  - Analysis methodologies, assumptions, guidelines
  - Establishing Teams to address analysis tasks
  - Options for filling analytical gaps
  - Use of Macro-System Model
  - Independent integration and assessment
- **Analysis Results**
  - Process for reviewing analysis results/conclusions
  - Presentation, documentation, cataloging of results
  - Utilization of results in decision support
- **Appendices**
  - Analysis Agenda
  - Multi-year schedule and funding estimates



FY04 Activities

- Identifying resources
- Staffing key/leadership positions
- Developing the Systems Analysis Plan
  - Including initial Analysis Agenda
- Coordinate across overall DOE Hydrogen Program (EERE, FE, NE, and SC)
- Initiating the Macro-System Model
- This Workshop

Staffing



Lead Systems Analyst (LSA)

- Systems Analysis planning/execution
- Interface to Technology Analyst
- Tech Team Support
- Risk Management Analysis
- Validation Analysis

Budget

- **Technology Analyst**
  - **overall budget disbursement**
- **Systems Integration**
  - **budget for cross-cutting and independent analysis**
- **Subprogram TDMs**
  - **budget for analysis unique, internal to subprograms**

Workshop Discussion & Products

Discussion Items Tomorrow

- **Key questions that Analysis should answer**
- **Analysis capability gaps/overlaps**
- **Development of common analysis guidelines and assumptions**
- **Opportunities for improved coordination**

From this Workshop

- From discussion items, important information and concepts for the Systems Analysis Plan
- Beginning of a "catalog" of hydrogen analysis capabilities
- Ideas on an "Analysis Repository"
- Recommendations on value-added next steps
- Increased coordination and communication within the analysis community

Capability Briefing Template

Name of Organization / Group

Presenter's Name
Title/Position

DOE Hydrogen, Fuel Cells, and Infrastructure Technologies Program
Systems Analysis Workshop
July 28-29, 2004
Washington, D.C.

Charter

- *Describe your organization's mission or objectives*
- *Describe your group's mission or objectives (group is the part of your org that actually does analysis)*
- *Describe your group's current/past funding sources for analysis projects*

History

- *Describe history of and how long your group has been doing analysis in general*
- *List significant past analysis projects (i.e., those no longer being worked on)*
- *Describe history and how long you've considered hydrogen in your analyses*

Skill Set - People

- *List past analysts that helped develop your group's capabilities*
- *List current analysts and their primary roles*

Skill Set – Models

(add slides as necessary)

- *List models that explicitly include hydrogen*
  - *Model name, dates in use, brief description*
  - *Modeling methodology (e.g., linear programming, thermodynamic, etc.)*
  - *Model platform (e.g., GAMS, ASPEN, etc.)*
  - *Model limitations*
- *List models that could be adapted to include hydrogen*
  - *Model name, dates in use, brief description*
  - *Modeling methodology (e.g., linear programming, thermodynamic, etc.)*
  - *Model platform (e.g., GAMS, ASPEN, etc.)*
  - *Model limitations*

Skill Set – Capabilities Summary

(Refer to H_2 Analysis Types – Slide 10)

TYPE OF ANALYSIS	RESIDENT CAPABILITY?	STUDIES SPECIFIC TO H_2?	MODELS SPECIFIC TO H_2?
Resource Analysis	*Yes or No*	*Yes or No*	*Yes or No*
Technoeconomic Analysis	*Yes or No*	*Yes or No*	*Yes or No*
Environmental Analysis	*Yes or No*	*Yes or No*	*Yes or No*
Delivery Analysis	*Yes or No*	*Yes or No*	*Yes or No*
Infrastructure Development Analysis	*Yes or No*	*Yes or No*	*Yes or No*
Energy Market Analysis	*Yes or No*	*Yes or No*	*Yes or No*

Studies

(add slides as necessary)

- *List significant past studies that relate to hydrogen*
- *List significant past studies that could be adapted to hydrogen*
- *List current/planned hydrogen studies*

Future

- *If your organization/group has firm plans/commitments to grow or expand your analytical capability (type, people, models, etc.), briefly describe*
- *On other hand, if you foresee a diminishment in capability, briefly describe*
- *This chart may be omitted if future is status-quo*

Analysis Issues

- *Open podium – what do you see as the major issues related to analysis of hydrogen systems?*

Summary

- **Capability presentations**
  - **Many to get through; important we stay on time**
  - **Questions for clarification only during 20 minutes of charts, followed by 10 minute Q&A**
- **Discussion period –**
  - **Interaction is important**
  - **We need to hear your concerns and ideas**
  - **Jot down items during 1st day which may be used on 2nd day**
- **Professional, considerate . . .**

Backup Charts

NRC: Sys Analysis Attributes

Attributes

Concept
- Well-funded, professionally staffed
- Separated by a fire wall from technology development functions
- Independent of the various DOE line R&D programs to minimize both the existence and the appearance of technology bias

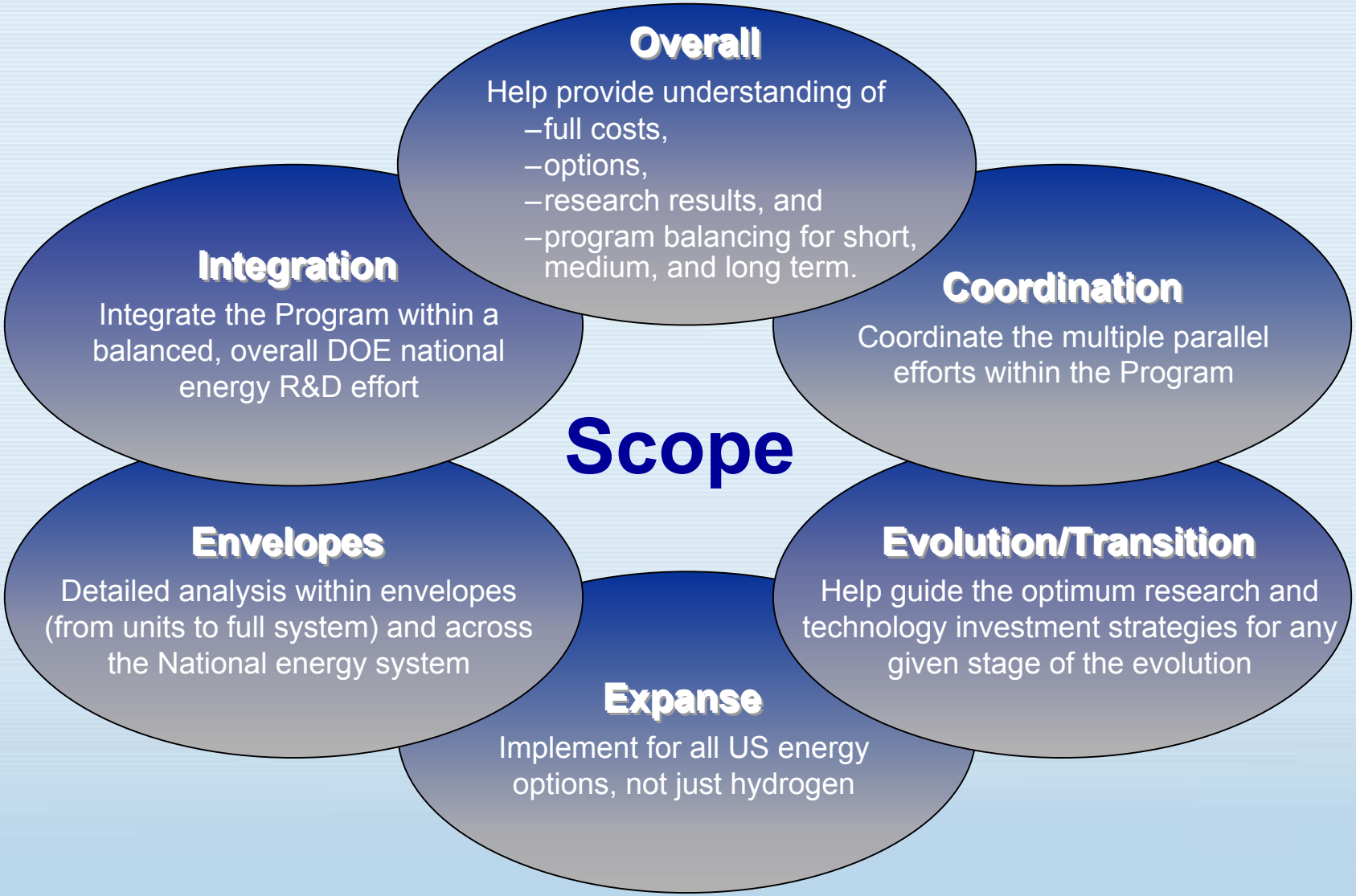
Funding
- Should be on the order of $10M per year – without such a level, research priorities and results will be less understood

People
- Most important ingredient is people
- Relatively few with the training, talent, and background
- Core of specially selected people is essential

Modeling
- Systems modeling for the hydrogen supply evolution should be started immediately
- Help guide research investments and priorities for the transportation, distribution, and storage of molecular hydrogen

- **Benefits** – to be expected:
  - An independent, consistent, unbiased description of technologies as they are and might be
  - A fact-based prescription to guide the selection and evaluation of research projects
  - A sound basis for estimating the potential benefits of research programs
- **Pitfalls** – to be avoided:
  - Poor quality or biased results have potential to severely damage institutional credibility and program direction
  - Guard against outside influences – can be inundated by those protecting their own preferences or projects

NRC: Sys Analysis Scope



NRC: Sys Analysis Tasks

- **Coordination of Multiple Parallel Efforts**
  - examine the many primary sources and various scales of production
  - analyze the options for distribution
  - investigate the cross-cutting challenges of safety, security, and environmental concerns
- **Integration with Other Energy Considerations**
  - study the place of hydrogen relative to other secondary energy sources
  - examine the competition between electricity, liquid fuel-based (e.g. ethanol), and hydrogen-based transportation
  - assess the interactions with end-use energy efficiency, e.g. hybrid vehicles
- **Investment/Results**
  - estimate what levels of investment are required over time
  - identify key costs, technological gaps, and prioritization of R&D efforts
  - evaluate the significance of actual research results
- **Transition**
  - map out and evaluate a Transition Plan
  - assess issues of timing and sequencing
- **Supporting Studies**
  - inventory/assess the systems and subsystems currently under development
  - examine different future energy scenarios and forcing functions that may impact the nation
  - develop an understanding of how proposed technologies might fit into a national system

Analysis Budget

Option 1 - FY05	Option 2 - FY06/Beyond
Description • SI has budget for SA core support as well as basic system-level, cross-cutting, or over-arching analysis tasks • Each subprogram continues to maintain its own analysis budget, for internal analysis as well as contribution to cross-cutting tasks	**Description** • SI has budget for SA core support as well as system-level, cross-cutting, or over-arching analysis tasks • Each subprogram contributes percent of its budget (probably different for each) to SI for cross-cutting analysis tasks • Each subprogram only maintains budget for analysis which is unique, internal to that subprogram
PROs • Systems Integration can provide added value through review and input into AOP planning and progress review, while TDMs maintain control over their subprogram $$ and analysis priorities. • SI can show leadership by working closely with TDMs to integrate the results of their individually controlled analysis portfolios, and by using these as building blocks for the macro-system model. • SI provides forum and opportunities for TDM inputs on consistent analysis tasks and methods • (TDM) Independent QC of planning and analysis results increases credibility/acceptance of analysis efforts	**PROs** • SI, TA and TDMs work as a team in defining the systems analysis portfolio for the Program, while TDMs maintain their own individual portfolios to support their subprogram needs. • Higher level system analysis supports the Program and subprogram needs, while analysis that is more closely integrated with the R&D is maintained. • CONs for Option 1 are lessened • (TDM) Eliminates duplication and redundancy of efforts, preserving $$ for R&D projects
CONs • Higher probability of inconsistencies and gaps across the analysis portfolio. • Near-term subprogram needs may not be the highest priority toward achieving Program success.	**CONs** • Some (e.g., NRC) may not see this as a truly independent systems analysis function

Analysis Examples

- **Technology Analyst**
  - Study Hydrogen Incorporation into NEMS
  - Analysis to directly support budget decisions/justification
- **Systems Integration**
  - Infrastructure Analysis – Pathways to Hydrogen
  - Transition Analysis: Renewable, Integrated Electricity, H2 Production
- **TDM/Subprogram**
  - Fuel Cell Stack/Component Cost Analysis
  - Risk Analysis for Underground Bulk Storage

Approx FY04 Spending by Analysis Area

Resource Analysis	$300K
Technoeconomic Feasibility & Cost	$2,250K
Environmental	$170K
Delivery	$70K
Infrastructure Development & Cost	$650K
Energy Market	$1,440K
Overarching/General	$1,710K

Budget Summary

- Option 1 acknowledges the significant current planning for FY05
- The transition to Option 2 does not indicate a need for more control -- rather it is an acknowledgement from the Team that there is a need for a higher level systems approach that still serves the needs of the individual subprograms
- Both options assume that TA has own budget for its internal operations and to fund Govt-only and near-term/quick-response analyses